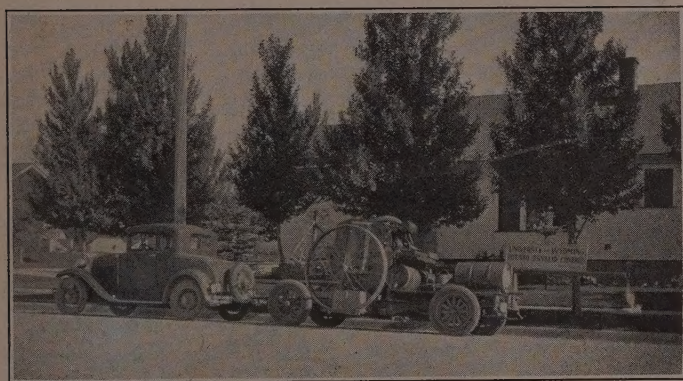


UNIVERSITY OF WYOMING
AGRICULTURAL
EXPERIMENT STATION



POTATO SPRAYING APPARATUS EN ROUTE.

A STUDY OF PSYLLID YELLOWS
IN WYOMING

Bulletins will be sent free upon request.

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A STUDY OF POTATO PSYLLID YELLOW IN WYOMING

BY GLEN HARTMAN

INTRODUCTION

The material presented herein and the conclusions made are based upon tests and observations during the last two seasons. Since weather and other factors apparently affect psyllid populations and reactions, more time is needed to complete the study. This is a progress report of the work to date.

The potato psyllid was first associated with a trouble of the potato previously known as "blight" and "purple-top," and later called psyllid yellows by B. L. Richards of the Utah Experiment Station in 1927. This disease has been confused with Rhizoctonia, leaf roll, and other conditions or diseases having similar symptoms. It is highly probable that this disease or trouble has been present in Wyoming for several years, but it has not been recognized as distinct, for the cause remained unknown until 1927.

It was announced by Richards that the tomato psyllid (*Paratriozia cockerilli*, Sulc.) was responsible for the disease. The insect and the disease of psyllid yellows in the potato plant were first reported together in the field by Metzger and Binkley at Fruita, Colorado, in 1928. In 1931 the disease was reported and observed in the irrigated section around Torrington. In some fields the losses were very great, but the epidemic was not generally distributed throughout the entire section. In 1932 the disease was reported from many irrigated sections throughout the entire state. In 1933 the trouble was not reported from any place within the state, except at Laramie, although it was reported from Colorado. During the seasons of 1934 and 1935, psyllids were reported in every potato-producing section of the state. To the writer's personal knowledge, heavy losses were sustained in Albany, Goshen, Laramie, and Platte counties, and in the valley of the Big Horn River from Riverton to the Montana line, during these seasons. During the season of 1936 the potato production in Wyoming was very low because of the drought. Losses

caused by psyllids were much smaller than during the two previous seasons. Psyllid damage was not very severe even in the irrigated sections of the state.

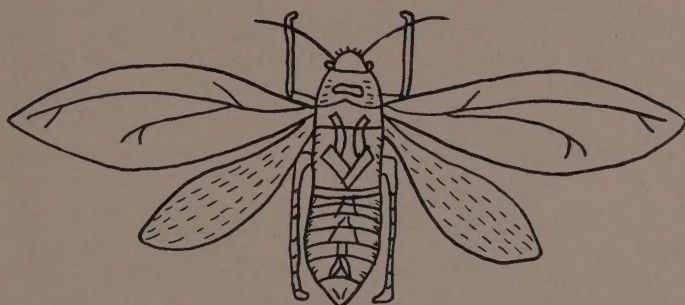
There is no potato disease or trouble known in Wyoming which spreads as rapidly and uniformly or causes the enormous losses that are caused by psyllids during certain seasons.

DESCRIPTION OF THE PSYLLID

Adult. The potato or tomato psyllid, known technically as *Paratrizzia cockerilli*, Sulc., is a small gray insect about 1/16 of an inch long, shaped very much like a very small cicada. The body of the insect is a gray color, and upon the front part of the abdomen is a distinct white band. There is a peculiar Y-shaped mark at the end of the abdomen. The wings are colorless, and, when the insect is at rest, they are folded roof-like above the body. The adult is very active, and although present throughout the season is seldom observed until late in the fall, owing to its habit of flying away when anyone approaches it. When the adult emerges from the last molt of the nymph, it is almost colorless and very inactive for the first 4 or 5 hours. The body soon colors, and then the insect becomes very active. (See Figure 1.)

Eggs. The eggs are small, elongated, and of a whitish-yellow color. They are placed on a slender white pedicle or stylet about 1/6 of an inch long. The eggs are laid by the adult female usually along the veins and margins of the under side of the leaves, where they may be observed sticking down like little pegs.

Nymphs. The immature forms are very small, about the size of a pin point, and brown or orange colored when first hatched. As they grow and develop, they pass through a series of molts, each stage becoming a little larger than the preceding one. As the molts progress, there is also a change in color, the brown and orange becoming greener. The mature nymph has a body which is nearly as large as the body of the adult and is light green in color. In the last nymphal stage the short wings are formed in small sacs and are clearly visible on the upper surface of the scale-like body. At this stage of development there



ADULT PSYLLID



IMATURE PSYLLID—NYMPH

FIG. 1. Two stages of growth of the potato psyllid. *Paratriza cockerilli*.

is a peculiar H-like marking upon the rear of the abdomen. The nymph is rather inactive when feeding and lies very flat and close to the surface of the leaf.

Life History. According to Richards, the life cycle of the psyllid takes place in from 11 to 23 days, depending upon weather and temperature conditions. The egg hatches in from 3 to 5 days, and the five stages of the nymph are passed in 15 to 20 days. The length of each stage varies and depends upon field and temperature conditions. The adult may live for several weeks. The average female lays several or many eggs.

DISTRIBUTION

Potato or tomato psyllids to date have been found in the Rocky Mountain and western states. They have been reported from Utah, Arizona, New Mexico, California, Washington, Oregon, Idaho, Montana, South Dakota, North Dakota, Kansas, Nebraska, and western Canada.

In Wyoming their distribution is extensive. Psyllids and psyllid injury have been noted in practically all parts of the state. During the seasons of 1935 and 1936, the writer has observed infestations of psyllids on potatoes in both the high mountain valleys and on the plains of the state.

HOST PLANTS

The preferred host plants of the psyllid belong to the *Solanaceae* or nightshade family of plants. Potatoes and tomatoes belong to this family. The list of wild native plants includes several species of wild ground cherries, wild tomatoes, buffalo bur, nightshades; in fact, there are very few of the wild members of this plant family that do not serve as host plants. Among the cultivated plants in Wyoming, the psyllids have been observed upon potatoes, tomatoes, egg-plants, and peppers. Recently psyllids have also been observed upon our native red cedars.

The relation of host plants to the abundance of psyllids has been regarded as important. The perennial *Solanaceae* serve as breeding grounds in the early spring and late in the fall. The native cedar trees probably serve as a winter host to the psyllid. In years when psyllids have been a most important agency in damaging potato fields, these native host plants have been found harboring large numbers of psyllids. In 1935 psyllid nymphs were abundant on the perennial ground cherry until November. After the first killing frost, a large number of plants near potato fields were found to have many psyllid nymphs upon them. Such plants as alfalfa, Canada thistle, bind weed, in fact, any plant which still retained some green leaves, was covered with the psyllid nymphs, if it was located near an infested potato field.



Fig. 2. Vine symptoms of psyllid yellows or purple-top.
Left—An infected vine. Right—A healthy vine.

PLANT SYMPTOMS

The complete list of symptoms which appear when a potato plant reacts to the effect of psyllid nymphs is very large. There is variation in number and intensity of the symptoms which actually appear. The following symptoms will assist in recognizing the presence of psyllid yellows in the field.

Psyllid yellows or purple-top is a disease or trouble of potatoes in which the leaves begin rolling, and as it develops, the curling becomes more extensive. The plants first show a slight yellowing along the midrib of the leaf. This is soon followed by a purple discoloration at the edge of the leaf. At the same time the young leaves of the plant begin to curl upward. As the disease progresses, the curling of leaves spreads to all parts of the plant. The leaves become harsh, thick, and leathery, and have a peculiar rustle and feel when brushed with the hand. The plants remain in an abnormal state of growth for a period of several weeks. There is no wilting, even under extreme drought conditions. In

the advanced stages the yellowing becomes more pronounced; the plant may die or it may remain alive until frost. The vines may continue to bloom for an abnormally long period. (See Figure 2.)

The underground symptoms are characteristic. In typical cases a mass of small tubers attached close to the stem, or on short stolons, is found. In the Bliss Triumph variety these small tubers are often of a brighter red than is normal. Frequently the small tubers are found in long chains. Apparently the first small tuber is formed upon a small or short stolon, then stolon growth is resumed and another tuber is formed. This is often repeated until a chain of several tubers is formed. Growth may be resumed by the stolon growing from the bud-end of the small tuber, or the stolon may branch just back of the stem-end of the tuber. Several such chains of tubers may be found in one hill. (See Figure 3.) Often more than 100 small tubers are found under one plant, none of which have attained a marketable size.

The exact symptoms which may be found underground seem to depend upon the stage of growth of the plant when psyllid infestation occurs. If the infestation is early, before tubers are normally set, the symptoms as listed are most commonly found. If the psyllid infestation does not occur upon the plant until the tubers have been set and partially grown, then further development of the tuber seems to be halted. In this case, the tubers seem to increase but little, if any, in size after vine symptoms are produced. The tubers already formed have a marked tendency to become rough in shape and intensified in color. If psyllids are not, in some way, removed from the plant or their effect counteracted, no further growth is produced in the tubers. However, if the plant recovers from the effect of the psyllids, often another set of tubers is grown. This second set of tubers never, under Wyoming conditions, reaches maturity or marketable size. Tubers from infested vines do not develop a normal rest period and have a tendency to sprout much earlier than is normal. Occasionally tubers have sprouted at digging time.

The yields of infested fields are usually low in potatoes of marketable size and quality, and a large number of small potatoes are produced. Growth and proper development are so completely upset that the plants are unable to produce normal tubers.

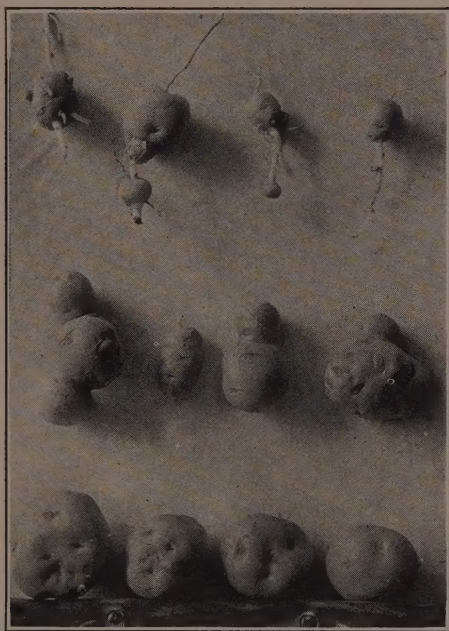


Fig. 3. Tuber symptoms.

Top row—typical psyllid symptoms. Second row—
drought symptoms. Bottom row—normal tubers. Bliss
Triumph variety.

FEEDING HABITS OF THE PSYLLID

The psyllid nymphs normally take a position on the under side of the leaves in the lower third of the plant. In large plants, where the foliage is abundant, the nymphs may sometimes be found upon the upper side of the leaves and even upon the stem of the plant. Since the bodies of the nymphs are small, flat, scale-like, and indistinctly colored they are difficult to see. When young, they stay close to the site where the eggs are laid and remain quite inactive in the early stages. They become quite mobile in the latter stages of development. The insects feed with sucking mouth parts, and when they are feeding they are very inactive.

There is little doubt that a secretion is injected into the potato plant. However, the nature of the agent which causes the disturbance in the growth of the potato is still not definitely known. The possibility of its being an enzyme has been indicated both in the field and laboratory.

The action of the lime-sulphur mixture in the control of the psyllid is not definitely understood. In many instances, numerous nymphs may be found upon a plant shortly after spraying, yet it responds to the treatment. The beneficial effects of lime-sulphur, when psyllids are present, may be due either to the reduction in the number of insects, the control of the relation of the insect to plant growth, or, more probably, to a combination of both.

A large number of tests have indicated that the disease is not carried over from one year into the next by tubers from infested plants. The symptoms of the disease are produced only by the feeding of the nymphs of the psyllid upon the plant. Results of two seasons' work have indicated that the vitality of the seed tuber may be slightly reduced when severe psyllid symptoms appear in the vines. However, if such seed is protected from further attacks of the psyllid, vitality is apparently regained in one season. In a test of one hundred strains of Wyoming Certified Bliss Triumph seed potatoes conducted at Fairhope, Alabama, in the winter of 1935-36, no measurable differences in yield could be found between samples taken from fields badly infested with psyllids and fields not infested or only slightly infested. Various workers in potato pathology have demonstrated the absence of virus in this disease.

It has not been known where or in what form the insect spends the winter months. Neither has the source of the first adult insects, which appear in the late spring or early summer, been determined. During the first days of May, 1936, Leslie B. Daniels of the Colorado State College of Agriculture, announced through the Associated Press that he had found potato psyllids in appreciable numbers upon red cedar trees. These psyllids were found upon red cedars in the sand hills of western Nebraska and in pro-

tected canyons in eastern Wyoming. At this time the psyllids were spreading from the cedars to the wild members of the *Solanaceae* family.

Beginning on June 23, 1936, an inspection tour was made through the potato producing area near Torrington and the eastern part of Laramie County. At this time psyllid nymphs and eggs could be found upon many of the wild members of the *Solanaceae* family and in all potato fields in which the plants had reached the early bloom stage of growth. The insects had apparently spread from the cedar trees by means of the wild *Solanaceae* plants until adult flies were present in all parts of the area.

During the seasons of 1935 and 1936, it was observed that as soon as one field in a given community was found to be infested with psyllids, they could be found some place within nearly every field in that same locality; especially was this true in fields which were planted before the first of June. Usually the first nymphs in a field are found around the edges of the field or in low places within the field.

It was also found that after infestation by psyllids occurred in any locality, some fields readily developed psyllid symptoms and produced very low yields. At the same time, other fields in the same community developed very few or no symptoms, and very good yields were secured. In no case were any psyllids found in the latter part of June in any potato field in which the plants had not reached the early bloom stage of growth.

Certified seed potato fields afford a very good opportunity to study the problem of variation in the damage from psyllids. In 1935, psyllid infestation of the potato fields in the certified sections did not occur until after July 10. Psyllid counts were made in fields at the time of first and second field inspections. The number of psyllids present and the damage done was found to vary greatly from field to field. Fields grown upon the same farm were found to vary in this respect. When the planting dates were compared, it was found that, almost without exception, the fields planted before the first of June showed the presence of large numbers of both

psyllid nymphs and plant symptoms. In the fields planted later, psyllids might or might not be easily found, but comparatively little damage was found. At digging time, it was found that the fields planted earlier gave very low yields of poor quality potatoes, while those planted later gave larger yields of higher quality potatoes, and fewer psyllid symptoms were present in the tubers harvested.

Because of greater psyllid damage in the early planted fields in 1935, most of the 1936 crop of certified seed potatoes was not planted until late, i.e., after the middle of June. At the time of the presence of large numbers of adult psyllid flies and eggs in the earlier planted irrigated sections during the latter part of June, certified seed fields had either not emerged or the plants were very small. No psyllids were found in these fields at this time. At this same time many eggs were found upon the vines of early planted fields. However, these eggs did not hatch, and hence heavy psyllid infestation did not occur even in the early planted fields. The psyllid infestation and the resultant damage to the potato crop was not nearly as severe in Wyoming during the season of 1936 as during 1935. However, the same relationships, with respect to psyllid infestation and damage, between the early and late planted fields were found during both seasons. Because of hot, dry weather conditions during June and July, 1936, very poor stands were secured in many of the late planted fields, except those which had been planted upon summer-fallowed land. During the 1936 growing season, poor stands were a greater factor in reducing yields than was psyllid injury.

In the experimental fields during both 1935 and 1936 the same relationships were found to be present, i.e., in fields planted during the first half of June, the unsprayed plots gave higher yields than the same plots in fields planted earlier. /

THE RELATION OF TEMPERATURES TO
PSYLLID INJURY

A review of the psyllid injury to potato production in Wyoming during the last five years shows that the extent of the damage varies greatly from season to season. In 1932 yields were greatly reduced. Probably a large part of this reduction was caused by psyllid injury, since precipitation that year was relatively high. In the season of 1933, no psyllid injury was reported or noted in Wyoming, except at Laramie. During the seasons of 1934 and 1935 psyllid injury was severe over the entire state. In 1936 psyllid injury was small in the eastern part of Wyoming, but rather severe injury occurred at Laramie.

A study of weather conditions prevailing in Wyoming during this five-year period was made. Psyllid injury appears not to be affected by fluctuations in the amount of precipitation received or by the time when such precipitation occurs. A direct relationship was found to exist between temperatures prevailing at certain times of the year and the extent of damage resulting the same year from psyllid injury. The minimum temperatures prevailing during the winter months and the maximum temperatures during the latter part of the month of June, appeared to influence greatly the extent of the injury to the potato crop resulting from the psyllids.

Table I shows the average minimum temperature of the winter months of December, January, and February and the estimated severity of psyllid injury to the potato crop at Laramie, Torrington, and Pine Bluffs during the years 1932 to 1936, inclusive.

TABLE I

Year	Laramie		Torrington		Pine Bluffs	
	Average min. temp.	Extent of Damage	Average min. temp.	Extent of Damage	Average min. temp.	Extent of Damage
1932	11.2	Severe	12.2	Severe	14.7	Severe
1933	4.2	Light ?	6.3	Light	5.8	Light
1934	21.0	Very severe	18.1	Very severe	20.2	Very severe
1935	16.4	Severe	15.1	Severe	15.5	Severe
1936	11.6	Severe	6.1	Light	9.3	Light

An examination of Table I shows that when the average minimum temperatures for the winter months were comparatively low, psyllid damage resulting the following season was light. If the winter average was comparatively warm the resulting damage was severe or very severe.

It would appear then that cold winters prevent serious infestations of psyllids and severe damage to the crop. Many details are lacking concerning the psyllid behavior for the years of 1932 and 1933. More of such information is available for the last three years. During the latter part of June, 1936, large numbers of psyllid adult flies and eggs were found in early planted fields at Laramie, Torrington, and Pine Bluffs. These eggs hatched at Laramie and infestation of nymphs resulted. However, at Torrington and Pine Bluffs all of the eggs did not hatch and a severe infestation did not result. Table I indicates a probability that the psyllids would have been killed during the previous winter at Torrington and Pine Bluffs, for this was one of the coldest winters of the five-year period. Nevertheless, many psyllids did appear at these places early in the season.

Average minimum and maximum temperatures during the last ten days of June and the first ten days of July were charted for Laramie, Torrington, and Pine Bluffs. Average minimum temperatures of this period showed no relationship to psyllid damage. The average maximum temperatures for the last ten days in June, the first ten days of July, the average for the twenty-day period, and the estimated psyllid damage at Laramie, Torrington, and Pine Bluffs are shown in Table II.

Data in Table II indicate that high maximum temperatures at this time of the season reduce the amount of damage done by psyllids. High temperatures, especially during the latter part of June seem to inhibit the development of the life cycle of the psyllid. This would explain why severe psyllid damage occurred at Laramie, but only light damage occurred at Torrington and Pine Bluffs.

Average maximum temperatures prevailing during the last of June and the first of July are probably more important in reducing psyllid damage than are the temperatures of the preceding winter.

TABLE II
Average Maximum Temperatures at Laramie.

Year	Last 10 days June	First 10 days July	20-day period	Estimated psyllid damage
1932	76.5	77.6	77.0	Severe
1933	80.3	79.5	79.9	Severe, but not as severe as in 1932
1934	78.1	77.5	77.8	Very severe
1935	74.1	79.9	77.0	Severe
1936	81.0	82.0	81.5	Severe, but not as severe as in 1935

Average Maximum Temperatures at Pine Bluffs.

Year	Last 10 days June	First 10 days July	20-day period	Estimated psyllid damage
1932	86.8	91.0	88.9	Severe
1933	94.8	91.4	93.1	Light
1934	90.9	90.9	90.9	Severe
1935	83.3	94.0	86.6	Very severe
1936	94.5	100.1	97.3	Very light

Average Maximum Temperatures at Torrington.

Year	Last 10 days June	First 10 days July	20-day period	Estimated psyllid damage
1932	86.0	89.9	87.9	Severe
1933	91.1	91.0	91.0	Some damage, not as severe as in 1932
1934	86.0	88.0	87.0	Severe
1935	83.3	90.7	87.0	Severe
1936	94.3	98.6	96.4	Very light

In reviewing the temperatures which have occurred during this twenty-day period, it is found that an average maximum temperature of 90 degrees, or more, for this period has occurred only six times in Goshen County during the last twenty-two years. These years were 1916, 1919, 1930, 1931, 1933, and 1936. In Laramie County the average maximum temperatures for the last ten days in June and the first ten days of July have reached 90 degrees six times in the last 18 years, i.e., 1919, 1930, 1931, 1933,

1934, and 1936. At Laramie the average maximum temperature for this period has never reached 90 degrees.

The 1936 growing season was preceded by a comparatively cold winter in Goshen and Laramie Counties. By June the twentieth, many adult flies and psyllid eggs were found upon all potato vines which had reached the budding stage of growth in both counties. The average maximum temperature during the last ten days of June rose to 94 degrees in both counties and very few of the eggs hatched into nymphs. The increase in psyllid population was therefore checked, and only slight psyllid damage occurred, except in a few very early planted fields. In these early planted fields the vines had bloomed, eggs had been laid and hatched on the vines prior to this time.

No reactions to psyllid nymphs have been observed before the potato plants reached the budding stage. This suggests that before this stage the plants either are not susceptible or are avoided by the egg-laying insects. Plants blooming in early July are likely to be visited by the psyllid fly, and receive eggs which hatch before the hot weather which sometimes occurs in late June. The nymphs do not appear to be destroyed by high temperatures occurring in the field, but will complete their life cycle. Since psyllids are spread from field to field chiefly by the egg-laying of the adult fly, high temperatures retard the increase in psyllid population and also the spread of the insect. During a normal season maximum temperatures rise well above 90 degrees in Goshen and Laramie Counties by the middle of July. Potato plants blooming after the middle of July are likely to be less heavily infested than those blooming two to three weeks earlier. This is probably the reason that in the past, potato fields planted about the first of June have been damaged less than fields planted earlier than the first of June.

Controlled experiments on the effect of temperature upon the development of the life cycle of the psyllid in the laboratory or greenhouse have not been possible in this study because of the lack of time and equipment. All the observations discussed here have been made in the field.

CONTROL EXPERIMENTS

Because of the serious nature of the disease known as purple-top, very determined efforts have been made to establish a control for the potato psyllid. Daniels of the Colorado Experiment Station, following his tests in 1932, reported as follows:

1. Lime-sulphur in a $33\frac{1}{3}$ per cent solution gave indications of controlling the condition.
2. Verdol, 1 per cent, showed no control.
3. Nicotine failed to show control.

In 1933, Daniels enlarged his test work and found that the lime-sulphur solution sprayed on the vines under high pressures, gave good results in controlling psyllids.

In 1934, potato psyllids were found upon the University Agronomy Farm at Laramie as early as June 28. Heavy losses from psyllids were sustained upon this farm and throughout the state that year. Because of the inability to secure the necessary special equipment, no control studies were made that year upon the Agronomy Farm.

Early in the season of 1935 a high pressure sprayer of the four-row type was purchased. A series of experimental plots were laid out upon the Agronomy Farm to test the effectiveness of spraying with lime-sulphur for the control of psyllids.

By means of an automobile trailer the spraying equipment was moved to test fields in other parts of the state during the seasons of 1935 and 1936, thus insuring uniformity of treatment throughout.

Early in June of 1935 and 1936, fields for testing purposes were selected near Lingle, Torrington, Albin, Pine Bluffs, and Egbert. In each case a small field or a portion of a large field was selected and divided into plats of equal size. The spraying program was so arranged that at the close of the season each field would contain plats which remained unsprayed; plats sprayed only once, but at different dates; plats sprayed twice, but with different combinations of dates; and plats sprayed three times during the

season. The owner of each field cooperated with the University in these tests.

Three tours were made to these fields with the spraying equipment. Counts were made of the psyllids and the plant symptoms.

Only a few of the cooperators were equipped to sort the potatoes into grades. Late in the growing season, a tour was made to these fields. At that time counts were made of the psyllids and the vine symptoms present in the plats. For the purpose of determining the effect of the spraying upon the quality of the tubers, ten-hill samples were dug by hand from each plat. These ten hills were selected for digging by first selecting a representative row in each plat. Then a hill with an average appearing vine was selected, this hill was dug, and beginning with this every fifteenth hill was dug. The method was used to avoid any personal factors in selecting the hills and to secure a sample which would be representative of the plat.

After careful and accurate sizing over a $1\frac{1}{2}$ inch screen in the dry-land fields and a $1\frac{7}{8}$ inch screen in the irrigated fields, the larger tubers were graded for certified seed in the dry-land fields and for U. S. No. 1 table stock in the irrigated fields. The tubers which remained upon the top of the sizing screen but which would not qualify for these grades were called grade No. 2. All tubers which passed through the sizing screen were designated as culls. The total weight as well as the weight of each grade was recorded for each sample. The total number of the tubers and the number in each grade were counted and recorded.

The width of the rows, the drop of the row, and the percentage of stand were determined for each field. Thus the number of hills per acre was calculated for each field, and the results of the ten-hill samples were converted into acre yields.

This method of obtaining acre-yields and grades was checked in several plats upon the Agronomy Farm at Laramie and found to be reasonably accurate and reliable. The yields obtained by this method also corresponded very closely to the yields reported by the cooperators.



Fig. 4. Right—Ten hills from an unsprayed plot. Left—Ten hills from a plot in the same field, but sprayed twice.

THE COST OF SPRAYING

The cost of spraying potatoes for the control of psyllids involves many factors which vary with each individual farm. The test fields studied were too small for the accurate determination of costs. It is hoped to secure an average cost figure arrived at by using data from every available source. Each potato grower will then be able to compare his own case with these average costs and to make the changes necessary to fit his own conditions.

Machinery. The type of spraying machinery varies from a cheap machine costing \$180 which will cover four rows at a time, up to machines costing \$800 to \$1000, which are drawn and operated by tractors and which will cover eight rows at a time. It is believed that if spraying is to be done each season, a reasonably good, high-priced machine will be the cheaper over a period of years. A horse-drawn, power-driven sprayer of the four-row type which includes most of the desirable features was used in this experimental work and found to be very satisfactory.

A machine, as above described, cost \$535 in the spring of 1935, delivered at any Wyoming shipping point. A sprayer of this type should last for at least five years if given reasonable care. The yearly depreciation charge is one-fifth of this amount or \$107. The interest rate to growers of this section is 8 per cent. In addition to the depreciation and interest, a charge of 10 per cent of the depreciation is allowed each year for repairs and replacements. The total yearly machinery costs including depreciation, interest, and repairs are \$131.10.

To obtain the best results from spraying, a field should be covered in a comparatively short time, say 10 days. With this type of machine 25 acres is about the upper limit of a day's work. Two hundred to 250 acres should be about the acreage which one sprayer of this type can care for during a given season. This is equivalent to a charge of from 52 to 65½ cents per acre. For this study 58 cents will be used as the machine cost regardless of the number of times a field is sprayed.

Labor. This type of sprayer requires a man and team to operate. It was found that, in most cases, 15 acres was an average day's spraying. Allowing wages of \$6.00 per day for the man and team, the labor charge for operating the sprayer is 40 cents per acre for each spraying.

Material. Lime-sulphur ready mixed could be bought in 1935 at the rate of \$15 for a 55-gallon drum laid down at Wyoming points, which is 27 cents per gallon. In most fields nearly 2 gallons of lime-sulphur per acre were used for each spraying, making the cost for materials 54 cents.

Water. In dry-land sections water for use in spraying must be hauled to the potato fields. The cost of getting this water to the fields varies from farm to farm. About 80 gallons of water are required to spray one acre once. Twelve hundred to 2000 gallons of water are required in the field each day. An 800-gallon galvanized iron tank which will fit upon a light truck can be purchased for about \$125. This amount prorated per acre in the same manner as the cost of the sprayer equals 13 cents per acre per

season. Computations based on truck hire at 6 cents per mile and driver's wages at \$3.00 per day show that the cost of hauling water will average about 33 cents per acre for each spraying.

Total cost of spraying. Machinery and equipment costs are the same throughout the entire season, whether the field is sprayed one or more times. Labor and material costs are the same for each application, and the cost of these items depends upon the number of sprays applied. Thus, in irrigated fields the total costs of spraying as determined in this study are: \$1.52 per acre for one application; \$2.46 for two; and \$3.40 for three applications. In the dry-land fields the cost of hauling water to the field must be added to these figures, making a total of \$1.98 per acre for one spray, \$3.25 for two, and \$4.52 per acre for three sprays.

METHODS USED IN CALCULATING RESULTS

Prices. In attempting to determine financial returns from spraying to control potato psyllids, the question arises as to what prices should be used in determining the value of the potato crop produced. Since this is a progress report and represents only two year's work, it has been decided to use prices and values prevailing in 1935 and 1936.

During the last week in November, 1935, the growers were receiving 80 cents per hundred pounds for U. S. No. 1 table stock and \$1.00 for certified seed potatoes for January delivery. During the same week in 1936, growers were receiving \$2.00 per hundred pounds for U. S. No. 1 table stock and \$3.00 for certified seed for January delivery. All test fields under irrigation were graded to U. S. No. 1 table stock and the fields under dry-land conditions were graded to certified seed requirements. Only the U. S. No. 1 or the certified seed was given a value for the purpose of these computations; all other potatoes harvested were considered as culls and valueless.

Shrinkage. From digging time (the time when figures for yield were secured) until January, there is considerable shrinkage and waste of potatoes in storage. In view of this fact, and since

most of the potatoes produced in this section of Wyoming are not sold until January, 20 per cent of the total yield was deducted for shrinkage.

Increased cost of handling crop. Increased yields increase the cost of handling the crop. These costs per bushel were: Picking $3\frac{1}{2}$ cents, sorting 6 cents, and sacks 6 cents each, or, a total of 18 cents.

Crop value. For the purpose of comparing the value of the different spray treatments, the value per bushel of the increase in the yield of salable potatoes from each plat in the ground at digging time was calculated.

Since prices were for January and an allowance of 20 per cent of the yields when dug was allowed for shrinkage and waste, the value of a bushel of salable potatoes for 1935 was 80 per cent of the January price, or 48 cents at digging time. Subtracting from this value the cost of handling a bushel of potatoes, which is 18 cents, leaves 30 cents, which represents the actual value of a bushel of certified potato stock before digging. For table stock the value in the ground would be 80 per cent of 48 cents per bushel less 18 cents handling cost, which equals 20.4 cents per bushel. By the same method of calculating, the value of a bushel of potatoes in the ground in 1936 was 78 cents for U. S. No. 1 table stock and \$1.26 for certified seed potatoes.

Increase in salable potatoes. The increased yields in salable potatoes were determined by subtracting the yield of salable potatoes in the unsprayed plat from that of each of the treated plats in the same field.

Value of increased yields. The value of the increase in yields of salable potatoes in each plat was determined by multiplying the increase in bushels of each plat by the value of a bushel of potatoes before digging. This figure represents the value of the spray treatment applied in any particular plat.

Net returns. The net returns resulting from the spray treatment are determined by subtracting the cost of applying the spray from the increase in value of salable potatoes which was produced by that treatment. Table III shows the total yield and grades harvested from each plat, the increase in salable potatoes due to spraying, the value of this increase, the cost of spraying, and the net return from spraying of each plat in test field No. 1.

TABLE III
Detailed Report of Results in Field Number 1. 1935.
Yields in bushels per acre. Value expressed upon acre basis.

	Unsprayed	Sprayed once early (1)	Sprayed once mid. (2)	Sprayed twice early and late (3)	Sprayed twice mid. and late	Sprayed all 3 times
Total yield	122.88	167.97	171.09	167.98	186.65	164.65
Culls	29.56	21.77	15.55	11.44	9.33	9.33
Grade No. 2	12.44	15.55	6.22	4.11	3.11	6.20
Certified seed	80.88	130.65	149.32	152.43	174.21	149.32
Increase in salable potatoes due to spraying . . . . .	.....	49.77	68.44	71.55	93.33	68.44
Value of increase in salable po- tatoes at 30 cents per bushel . . . . .	.....	\$14.93	\$20.53	\$21.46	\$28.00	\$20.53
Cost of spraying . . . . .	.....	1.98	1.98	3.25	3.25	4.52
Net returns for spraying . . . . .	.....	12.95	18.55	18.21	24.75	16.01

(1) "Early" means sprayed early in season about July 13, pre-bloom.

(2) "Mid." means sprayed in mid-season, about July 30, post bloom.

(3) "Late" means sprayed late in season, about August 15.

RESULTS AND DISCUSSION OF TESTS UNDER DRY LAND CONDITIONS

Table IV presents the total yields, the yields of certified seed potatoes, and the net profits per acre of all spraying tests in the four dry-land fields in 1935. Yields are expressed in bushels per acre.

TABLE IV
Consolidated Report of Results on 4 Dry land Fields, 1935.

Field number	Unsprayed	Sprayed once early	Sprayed once mid.	Sprayed once late	Sprayed twice early and late	Sprayed twice early and mid.	Sprayed twice mid. and late	Sprayed 3 times
1. Total yield	122.88	167.97	171.09	.....	167.98	186.65	.....	164.65
2. Total yield	84.99	91.52	93.70	.....	89.34	93.70	.....	106.78
3. Total yield	91.96	.....	125.60	116.63	.....	.....	132.33	.....
4. Total yield	40.11	.....	72.78	74.27	.....	.....	80.21	.....
1. Cert. seed	80.88	130.65	149.32	.....	153.43	174.21	.....	149.32
2. Cert. seed	39.22	50.12	63.20	.....	63.19	65.37	.....	84.97
3. Cert. seed	44.85	.....	107.83	100.93	.....	.....	112.15	.....
4. Cert. seed	4.46	.....	16.34	34.16	.....	.....	46.05	.....
1. Net return	.....	\$12.95	\$18.56	.....	\$18.22	\$24.75	.....	\$16.02
2. Net return	.....	1.29	5.21	.....	3.94	4.59	.....	9.20
3. Net return	.....	.....	16.92	14.84	.....	.....	16.94	.....
4. Net return	.....	.....	1.58	6.93	.....	.....	11.02	.....

In total yields per acre three sprayings gave the highest average increase in production, with an average increase of 50.73 bushels per acre over the unsprayed plats. In the production of certified seed the combination of two sprays, one applied early and one during mid-season, gave the highest average increase.

Each spray treatment gave an increase in both yield and quality. The largest increase from any single application of the lime-sulphur spray was secured when the potato plants were in full bloom but before many of the blossoms had fallen. A single application of lime-sulphur applied in the very early stages of blooming was more effective than a single application at any later stage of growth.

Since the fields tested did not receive any rain between the time of applying the early and mid-season sprays, part of the vines in the early sprayed plats were still covered with lime-sulphur at the beginning of the blooming stage of plant growth. However, the new growth produced by the plants in these plats was not covered with lime-sulphur at this time. This may account for the fact that the early sprayed plats showed some benefits because of the early spray but were not benefitted as much by a single spray as those plats which were not sprayed until mid-season, or at the beginning of the blooming period.

Since no field was observed to be badly infested with psyllids or show symptoms of psyllid troubles until after the plants had begun to bloom, it may be that the potato plant is not susceptible to damage by psyllids until it has reached the blooming stage. Many fields in the blooming stage were observed to be badly infested with psyllids and showed severe symptoms of psyllid troubles, while adjacent fields which were planted later and not yet in bloom contained very few if any psyllids and showed no symptoms of psyllid troubles. As pointed out before, late planted fields were less affected by psyllids than were early planted fields in the same community.

A lime-sulphur spray applied after the blooming stage was not very effective in increasing the yield and quality, if the vines had not been sprayed before. In this case an abnormally large number of tubers had been set, and the plant could not grow them to a marketable size.

A second spray applied after the blooming period was effective in increasing yields and quality of the tubers, if the vines had also been sprayed in the early stages of the blooming period. These two applications apparently enable the plant to develop a normal or nearly normal set of tubers.

A combination of two lime-sulphur sprays, one applied in the early stages of bloom and the other following the blooming period, gave the largest returns in yields and quality in most of the dry-land fields tested and observed. The one year of tests and ob-

servations indicates that, with this as with other treatments or no treatment, the later plantings are less injured by psyllids than the earlier ones.

The improvement in quality, especially in the matter of true-ness to type, was very noticeable in the sprayed plats when compared to the unsprayed plats in the same fields. There was also a marked improvement in the color of the tubers. This is very important to the producer of seed potatoes.

Table V presents the total yields, the yields of certified seed potatoes, and the net returns or losses per acre of all spraying tests in four dry-land fields sprayed in 1936. Yields are expressed in bushels per acre.

TABLE V
Consolidated Report of the Results on 4 Dry Land Fields, 1936

Field number	Unsprayed	Sprayed once early	Sprayed once mid.	Sprayed once late	Sprayed twice early and mid.	Sprayed twice early and late	Sprayed twice mid. and late	Sprayed 3 times
1. Total yield	82.14	82.14	59.14	95.28	78.85	72.28	95.28	95.28
2. Total yield	81.03	68.57	74.80	.....	74.80	.....	68.57	74.80
3. Total yield	102.85	108.00	.....	.....	.....	.....	92.57	107.99
4. Total yield	11.01	.....	10.91	13.79	.....	.....	16.52	.....
1. Cert. seed	59.14	55.86	49.29	78.86	59.14	52.57	88.82	82.14
2. Cert. seed	65.45	49.87	56.10	.....	56.10	.....	56.10	59.22
3. Cert. seed	87.42	95.14	.....	.....	.....	.....	77.14	89.99
4. Cert. seed	2.75	.....	4.08	2.75	.....	.....	8.26	.....
1. Net return	.....	-\$6.11	-\$14.39	-\$22.87	-\$3.52	-\$11.80	\$33.88	\$24.46
2. Net return	.....	-20.37	-13.76	.....	-24.01	.....	-15.03	-12.37
3. Net return	.....	7.75	.....	.....	.....	.....	-16.20	-1.23
4. Net return	.....	.....	-0.30	-1.98	.....	.....	3.42	.....

Spraying appears to produce net returns definitely in only one field (No. 1) in the test. This was an early planted field, and the psyllid nymphs could be found only at the time of applying the last spray. One plot in field No. 4 had a yield which indicated a

small net return for spraying twice. However, soil variation could easily have caused this small increase in production, since soil conditions improved across the field from the unsprayed plat toward the plat sprayed three times. Early applications of the spray and applications late in the season in fields where no nymphs were found, caused a reduction in the yield of potatoes. These losses in yields were relatively small, and when compared to the probable error are not significant. Psyllid nymphs were not found in any of the fields except in field No. 1 and then only late in the season. This would indicate that the application of lime-sulphur spray is not beneficial to the growth of potatoes if psyllid nymphs are not present upon the vines at the time the spray is applied.

Psyllid nymphs were not found in field No. 1 until after the first blooms had appeared, although nymphs were present before this time in some adjacent fields which had been planted very early and were in bloom.

RESULTS IN IRRIGATED FIELDS

Table No. VI shows the total yields, yields of U. S. No. 1 table stock, and the net returns per acre of all spray tests in the three irrigated fields for 1935. Yields and net returns are expressed upon the acre basis.

TABLE VI
Consolidated Report of Results on 3 Irrigated Fields, 1935.

Field number	Unsprayed	Sprayed once early	Sprayed once mid.	Sprayed twice early and mid.	Sprayed three times
1. Total yield	144.99	221.62	241.50	267.07	278.44
2. Total yield	343.04	351.20	400.21	420.63	420.62
3. Total yield	61.41	136.79	139.58	201.00	231.71
1. U. S. No. 1	53.98	159.11	167.63	227.30	238.62
2. U. S. No. 1	208.27	257.27	306.28	326.70	330.78
3. U. S. No. 1	5.58	25.12	25.12	100.50	120.04
1. Net return	.....	\$19.92	\$21.66	\$32.89	\$34.26
2. Net return	.....	9.99	18.47	21.69	21.59
3. Net return	.....	2.11	2.11	16.91	19.95

A total of three tests were made in irrigated fields. Two of the three fields were planted soon after the first of June. The other was planted earlier. The yield of potatoes was much higher for the unsprayed plats in the late-planted fields. The yields in the sprayed plats were also much greater in the late-planted fields; however, spraying produced the largest percentage of gain in the early planted field. The most effective single spray in these fields was the one applied in the blooming stage of growth. The net return from two applications was nearly as large as for three. The average net return for making two applications of lime-sulphur sprays in these fields was \$23.83 per acre.

Table VII shows the total yields, yields of U. S. No. 1 table stock, and net returns or losses produced by spraying for the two irrigated fields tested in 1936. Yields and returns are expressed upon the acre basis.

TABLE VII
Consolidated Report of Results in 2 Irrigated Fields, 1936

Field number	Unsprayed	Sprayed once early	Sprayed once mid.	Sprayed twice early and mid.
1. Total yield	113.89	121.00	121.69	169.02
2. Total yield	211.70	213.33	177.23	219.89
1. U. S. No. 1	61.46	65.30	49.94	109.48
2. U. S. No. 1	164.10	162.46	124.72	154.25
1. Net return	.....	\$1.48	—\$9.50	\$34.99
2. Net return	.....	—2.80	—32.24	—10.14

Tests were completed in two irrigated fields in the North Platte Valley in 1936. The summarized results in these fields are shown in Table VII. Both fields were planted in May. A few psyllid nymphs were found in field No. 1 early in the season. A field of very early planted Cobbler potatoes along the south edge of this field had reached the full bloom stage of growth and showed 85 per cent psyllid symptoms at the time of first spraying in this field. No nymphs were found in this field at any other time during the season. It will be noted in the above table that there was an increase in the yield of tubers in each plot which was sprayed at this time. The plot which was not sprayed until later showed a decrease in the yield of U. S. No. 1 potato tubers when compared with the unsprayed plot.

Field No. 2 in this same test showed a reduction in yield in every sprayed plot when compared to the unsprayed plot. This was a small field isolated from any other potatoes. Psyllid nymphs were not found in this field at any time during the season.

The test work in irrigated fields during 1936 again suggests that there is no benefit to be derived from the use of lime-sulphur spray upon potatoes if the psyllid nymphs are not present upon the vines at the time the spray is applied.

DATE OF PLANTING AND SPRAY TEST

In 1936 a series of six plats of Bliss Triumph potatoes was planted on the Agronomy Farm at Laramie at different dates, beginning on April 16 and planted at two-week intervals until June 25. This entire piece of land had the same previous history and was prepared alike in the spring of 1936. The same source of seed was used throughout the entire test.

Each date-of-planting plat was subdivided into three plats. In each case, except the two last dates of planting, three applications of spray were given to one small plat, two to another and the third was left unsprayed. On July 7 the first spraying was made on all plats except those planted June 11 and June 25. The first spraying on these two plats was on July 25. Flower buds had formed in all plats except those planted May 28, June 11, and June 25 by the time the first spray was applied. The last application on all plats was on August 17 and September 7.

In the plots planted on April 16, April 30, and May 14, three sprayings were more effective in increasing yields than two. In the plantings after May 14, two sprayings were more effective than three, thus indicating that early planted potatoes should receive more applications of lime-sulphur spray than late plantings.

In the two plats planted June 11 and June 25 spraying early before blooms had formed upon any of the plants, caused lower yields than those secured from the unsprayed portion planted upon the same date. This indicates that the lime-sulphur spray may be injurious to the potato plant if applied to the plant before it reaches the beginning of the blooming period.

A few psyllid nymphs could be found distributed over the unsprayed parts of this field early in the month of July. The number of the nymphs in the unsprayed plats did not appear to increase until during the latter part of August. At this time both the number of nymphs and the amount of plant symptoms increased. No nymphs were found in any plat until after the potato plants had reached the budding stage of growth. Hence, the plats planted after May 28 escaped the infestation of nymphs which developed early in July, and did not show any psyllid nymphs until after the

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GENERAL DISCUSSION

During the last five or six years the potato psyllid has caused very heavy losses in potato production in Wyoming. The extent of the loss varies from season to season. During the season of 1935, psyllid infestation of potato fields began late in June and increased in intensity throughout the growing season. Losses in yields were great. Early in the season of 1936 psyllid nymphs in small numbers and many eggs of the psyllid were found in several early planted fields of Bliss Triumph potatoes. However, most of the eggs did not hatch and the infestation of nymphs did not become nearly as heavy as in the previous year, except in the high altitude sections.

It is now believed that the winter home of the potato psyllid is local, probably upon our native cedar trees. The insect spreads and increases in numbers in the spring upon our native *Solanaceae* so that by the latter part of June they are sufficiently increased in numbers and well enough distributed to produce serious infestation in all potato fields. Whether or not a serious infestation develops at this time appears to depend upon weather conditions. Maximum temperatures may or may not rise high enough at this time for a sufficiently long period to check the development of the life cycle of the insect. Hence, in the light of our present knowledge of this subject, it seems to be impossible to forecast the seriousness of the probable psyllid damage before about the first of July, or about the time spray treatment should begin.

Potatoes in the field appear to be damaged but little, if any, by potato psyllids until the plants have reached the budding stage of growth. Fields planted after the first of June appear to be damaged to a lesser extent than fields planted before the first of June. In the season of 1936, weather conditions during June and July caused poor stands to be produced in fields planted after the middle of June. These poor stands were a greater factor in reducing yields this season than were the psyllids. Observation shows that the weather conditions prevailing in 1936 are perhaps the exception rather than the rule. However, if it is desired to use planting later than the first of June, in helping to control psyllid damage, it

may be advisable to summer-fallow potato land or use some other method of conserving early spring or winter moisture so that the moisture may be present to produce the desired stand.

Spraying with lime-sulphur solution has been tested as a means of controlling the damage caused by the potato psyllid. Tests were made in both dry-land and irrigated fields and upon the Agronomy Farm at Laramie. The variety used in these tests was Bliss Triumph. In every case where psyllid nymphs were present in the field, the yields were increased by one or more applications of the spray. After deducting the cost of spraying and the extra cost of harvesting and handling the additional yields, two applications gave as large or larger net returns in late planted fields than did three applications. However, in the case of early planted fields, three applications gave the larger returns. The first spray should be applied at about the time the plants begin to bloom, followed by the second spray about two to three weeks later, and, in the early planted fields, by the third spray ten days to two weeks after the second. Net returns per acre produced by spraying have been as high as \$24.75 upon the dry land and \$32.89 in irrigated fields. Methods, time, and number of sprays for best results are the same under dry-land and irrigated conditions. Net returns from spraying were much larger during 1935 than in 1936.

In addition to the gains in yield resulting from spraying in infested fields, the tubers showed marked improvement in quality. In the sprayed plats the tubers were larger, more true to type, and carried a more desirable color than did the tubers harvested from unsprayed plats in the same fields.

Results of the spray test for the season of 1936 indicate that there is no beneficial result to the potato plant, measured by resulting yields, from the application of lime-sulphur spray if psyllid nymphs are not present upon the potato vines at the time the application is made. There are also indications that if nymphs are not present, the spray may be detrimental to the producing ability of the plant when applied too early.

It now appears that the spraying of potatoes for control of psyllid damage is advisable and may become necessary for profit-

able potato production, if some other method of control is not found. In the light of our present knowledge of the subject, it would seem advisable to have the necessary machinery and supplies at hand and to begin spraying as soon as psyllid infestation is noted in the field. When more is learned concerning the development of the insect under varying weather conditions, it may be found to be profitable not to spray during certain seasons, while in other seasons spraying will pay large dividends.

A few tests have been conducted to determine the effect of pressures used in applying the spray. They indicate that, while the use of low pressures produces at least some beneficial results in infested fields, the higher pressures are much more effective. The net returns per acre are higher when high pressures are used even though the first cost of equipment is greater. A maintained pressure of from 300 to 400 pounds per square inch gave the most complete and profitable returns as measured by yields.

The actual cost of spraying will vary somewhat in different localities and in different fields. The cost will be higher upon dry-land farms than upon irrigated farms. This is because of the necessity of hauling water to the fields upon the dry farms. The cost per acre for two applications, as determined in this study, is \$3.25 per acre upon dry-land fields and \$2.46 per acre upon irrigated fields.

To date, there is no indication that the symptoms produced upon potatoes by the action of psyllids are in any way carried from one season to the next by seed tubers from infested fields. The disease occurs only after psyllid nymphs have been present upon the vines.

Stomach poisons such as zinc arsenite and lead arsenate may be mixed with the lime-sulphur solution for the control of chewing insects such as beetles and leaf hoppers. None of these poisons or the lime-sulphur itself are effective in controlling some of the sucking insects such as aphids. Since aphids are a factor in the spread of certain virus diseases of the potato, more study should be given to the proper additions to the spray to secure aphid control.

There are indications of varietal resistance to the effects of the potato psyllid. The varieties Pearl, Late Ohio, and Irish Cobbler show a great deal of resistance. The Pearl and Late Ohio varieties are quite well adapted to irrigated conditions, and the Cobbler does well under either dry or irrigated conditions. The use of these varieties may help solve the psyllid problem for the small grower who produces only for his own use. In this case, the variety is not of great importance. However, the commercial grower cannot so easily change varieties, since the variety which he should grow is determined largely by his market demands.

It should always be borne in mind when reading this bulletin, that all conclusions and suggestions offered herein are based upon only two year's study and observation.



Fig. 4. Spraying potatoes for psyllid control.

THE APPLICATION OF THE LIME-SULPHUR SPRAY

In the application of the lime-sulphur solution certain principles should be kept in mind. To obtain the highest degree of control the spray should be applied to the plants at a pressure of from 300 to 400 pounds per square inch. This pressure should be maintained upon all nozzles at all times. The high pressure is necessary for two main reasons, first, to break the spray up into a very fine mist which will adhere to all parts of the potato plant, and second, to so move the foliage of the plant that all parts, especially the under side of the leaves, are covered.

Equipment. Because of irregularities in the surface of the ground upon dry-land farms and the variation in depth of the row ditches upon irrigated farms, a sprayer covering four rows is generally as wide as is satisfactory. Larger booms are difficult to handle and to keep properly adjusted to the row and the plants. Motor driven pumps have proved much more effective than traction driven pumps. The pump should be well constructed and

easily adjusted and repaired. It should have enough capacity to maintain a constant pressure of at least 350 pounds per square inch. This size and type of pump will require a four or five horsepower motor. The spray boom should be flexible, well supported, and easily adjustable for width of row and height from the ground. Since best results are obtained by the use of nozzles with very small openings in the spray disks, the sprayer should be equipped with very efficient strainers. There should be a strainer for all materials which go into the tank. There should also be a strainer between the pump and the boom. These strainers should be so constructed and located that they are easily cleaned. Much time may be lost in the operation of the sprayer due to clogged nozzles and valves.

Adjustments. Each modern sprayer is now accompanied by printed instructions and directions for the operation, care and adjustment of the particular sprayer. These should be carefully studied. The following general instructions will apply to any make of sprayer.

The pump should be adjusted to maintain the desired pressure uniformly. All screens should be kept clean and nozzle disks should be changed often. When the holes in the disks become enlarged through wear the results are (1) the use of too much liquid per acre and (2) the inability of the pump to maintain pressure. About 80 gallons of solution should be used per acre on irrigated fields and, perhaps a somewhat smaller amount on dry-land fields where the rows are wider. The use of too much solution or a lowering of pressure upon the pressure gage is usually an indication of the need of new disks in the nozzles.

The position in which the nozzles are placed with reference to the plant is of great importance. There should be three nozzles to each row, one above and one on either side and below the plant foliage. Perhaps the best arrangement is to offset the top nozzle from eight to ten inches in front of the boom center. The other two nozzles should be set close to the ground and spray upward. One lower nozzle can be directly below the boom center. The other lower nozzle should be offset eight or ten inches behind the

center of the boom. In this arrangement, no two nozzles are working directly against each other. As the sprayer moves forward the spray from each of the three nozzles strikes the plant at slightly different times. This causes a twisting or rotating effect upon the plant which has a tendency to move the foliage of the plant so that both the top and the bottom of all leaves are covered with the solution.

The distance of the nozzles from the plants will vary with the size of the plants. The nozzles are set close for small plants and farther away for larger ones. The top nozzle should be set high enough to cover the entire plant when the variation of the width of the row, the size of the plant, and the "wobble" of the sprayer are considered. In general the two lower nozzles should be placed as low as possible and from six to eight inches on either side of the plant. The angle of these lower nozzles should be adjusted upward so that the bottom of the cone of spray from each nozzle will strike the very bottom of the above ground plant or slightly lower. All of the lower leaves must be struck by the spray cone so that they will be moved and covered on the under side.

It is better to spray potatoes just before cultivating than immediately after. The cultivation will cover and pin down many of the lower leaves and branches of the plant so that it is impossible to secure good coverage of these leaves.

All parts of the sprayer which come into contact with the spray solution should be thoroughly washed with clean water at least once daily when the sprayer is in use. It should always be washed and drained before leaving it stand idle even for a short time. Every precaution possible should be taken to prevent the loss of time in operation. In order to preserve the wooden tank, some clean water should be left in the tank, except when exposed to freezing weather.

Sprays. The liquid lime-sulphur (32° Baume) is ordinarily used and is sold in steel drums of 50- or 55-gallon capacity. These drums should be kept closed air tight. One gallon of this solution is mixed with 40 gallons of water. The water should be strained into the tank first, the lime-sulphur should then be strained into

the tank. The running of the pump a minute before opening the nozzles will mix the solution.

Zinc arsenite may be added to the lime-sulphur solution for the control of potato beetles and flea beetles. First, combine the lime-sulphur and the water. Then use two pounds of zinc arsenite for each forty gallons of water. Thoroughly emulsify and mix the dry zinc arsenite in a large pail of water. Add it to the tank slowly through a mesh screen while the sprayer pump and agitator are in motion. Do not allow the pump or agitator to stop while the zinc arsenite is in the tank. Zinc arsenite is not soluble in water. Every precaution should be taken to prevent it from settling out of the solution. If settling occurs much trouble will be experienced with clogged valves and nozzles. Lead arsenate is some times used, but this will give more mechanical trouble than the zinc arsenite. Zinc arsenite is poisonous to man and animals and should be handled accordingly.

SUMMARY

The damage to the potato known generally as psyllid yellows is caused by the small potato or tomato psyllid, known scientifically as *Paratriza cockerelli*, Sulc.

The losses in potato production caused by psyllids have been very severe in Wyoming during the past five or six years. The extent of the loss varies from season to season.

It is now believed that the winter home of the potato psyllid is local. These insects probably increase to numbers sufficient to produce damaging infestations in potato fields by the latter part of June or the first part of July. The severity of the infestation appears to depend upon temperature conditions at this time.

Potatoes in the field appear to be damaged but little, if any, by potato psyllids until they have reached the budding or early blooming stage of growth.

Potato fields planted the first of June appear to be damaged to a lesser extent than fields planted before that time. The danger of poor stands resulting from late plantings should be considered.

Lime-sulphur is an effective control for the damage to yields of potatoes caused by the potato psyllid. Pressure of from 300 to 400 pounds per square inch should be used in applying the spray. Three sprays should be applied per season in early planted fields, while two applications seem to be sufficient in late planted fields.

Spraying potato vines before the first flower buds appear does not seem to benefit the potato plants and may result in injury.

Spraying potato fields when psyllid nymphs are not present upon the vines gave no beneficial results in 1936 when yields were used as a measure.

Where psyllid nymphs were present upon the potato vines, spraying with lime-sulphur spray increased the yield and improved the quality of the tubers harvested.

There is not, at present, any known method of forecasting the extent of psyllid infestations before the first of July each year.

There is no indication that the symptoms produced upon potatoes by the action of psyllids is carried from one season into the next by tubers from affected plants. The symptoms are produced only after psyllid nymphs have been present upon the vine.

A few standard varieties appear to be partially resistant to the effects of the psyllid. These varieties may be used by the small grower for home consumption but are not to be recommended at the present time for the commercial potato grower in Wyoming.

This is a progress report of two years' study of this subject.